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EAST MALLING RESEARCH

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Tests of the phytotoxicity of sulphur to blackcurrants 2004

Undertaken for Defra and the GlaxoSmithKline/HDC growers fund (Defra project HH3115TSF.)

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Authentication

I declare that this work was done under my supervision according to the procedures described herein and that this report is a true and accurate record of the results obtained.

Signed……………………………………………………………..
J. V. Cross

Dated………………………………………………………………

East Malling Research is an officially recognised efficacy testing organisation (Certification No. ORETO 043)

Tests of the phytotoxicity of sulphur to blackcurrants, 2004

Summary

A field experiment was done at East Malling Research in 2004 to determine the phytotoxic effects of foliar sprays of sulphur (12.5 l of 800 g/l sulphur SC in 500 litres water /ha) applied with a hand lance just before grape emergence (Growth stage C3-D) or at the end of flowering (GS I2-I3), or of two sprays one at each of these timings, on the yield and growth of the blackcurrant varieties Baldwin, Ben Gairn, Ben Hope Ben Lomond or Ben Tirran, in comparison with untreated controls.

- The treatments caused clearly visible symptoms of phytotoxicity on all the varieties except Ben Tirran.
- The two spray (pre-grape emergence + end of flower) treatment caused the most severe phytotoxicity, followed by the end of flower treatment with the least phytotoxicity being caused by the pre-grape emergence treatment.
- The severity of the visual phytotoxicity symptoms differed markedly between varieties. Symptoms were most severe on Ben Gairn where the lower leaves were blackened, followed by Baldwin. Ben Hope and Ben Lomond showed only slight symptoms. The effects of the treatments were barely perceptible on the Ben Tirran
- The yields of Ben Lomond and Ben Tirran did not appear to be reduced significantly by any of the sulphur treatments.
- The pre-grape + end of flowering sulphur treatment reduced yield by 19% averaged across all varieties, but by 27% on Baldwin.
- The single end of flowering treatment reduced yield by 13.5% on average with strongest treatment effects on Baldwin.
- The pre-grape emergence spray reduced the yield of Baldwin by 17%, but did not significantly reduce the yields of the other varieties.
- The severity of the phytotoxicity caused by the end of flower sprays may have been exacerbated by the high temperatures (20.5-25.0 ºC) when treatments were applied. In the 2003 experiment, where phytotoxicity from post flowering sprays was less pronounced, temperatures at the time of application were lower, 14 ºC and 21 °C for the sprays at the end of flower and 2 weeks later respectively.

Introduction

In project HH3115TSF, jointly funded by Defra and the GlaxoSmithKline blackcurrant grower's research fund, a 3 year series of experiments is being done at East Malling Research to determine the phytotoxic effects of foliar sprays of sulphur on blackcurrant. The conclusions of the first experiment done in 2003 (Cross and Harris, 2004) were as follows:

- A single foliar spray of sulphur (12.5 l of sulphur 800 g/l SC in 500 l water/ha) applied just before flowering was phytotoxic to 2 year old bushes of the blackcurrant varieties Ben Gairn, Ben Hope, Ben Lomond, Baldwin and Ben Tirran causing leaf discoloration, an 11.4% reduction in yield and possible slight reductions in growth.

- A single spray just of sulphur just after flower did not significantly reduce yield or growth.
- A programme of 3 sprays, one just pre-flowering, one post flowering and a third approximately 14 days later, caused greater phytotoxicity than the single pre-flowering spray, reducing yield on average by 14.6%.
- The data suggests that Baldwin may be more sensitive to sulphur than the other varieties, but this could not be proven by detailed statistical analyses.

Here we report the results of the second experiment done in 2004. The objective was to conduct a field experiment to determine the effects of a foliar spray of sulphur applied just before grape emergence or at the end of flowering, or of two sprays one at each of these timings, factorially, on the yield and growth of five blackcurrant varieties in comparison with untreated controls.

Methods and materials

Site

The same experimental plantation (CE 179; MR O.S. Landranger 188 699582) planted in March 2002 with 1 year old bushes at East Malling Research used for the sulphur phytotoxicity experiment in 2003 was used again in 2004, but the plots were-re-randomised (see 'Experimental design' below and Figure 1). The experimental plantation consisted of ten 4 x4 Latin squares, 2 of each of the varieties Baldwin, Ben Gairn, Ben Hope, Ben Lomond, Ben Tirran. The row spacing was 3.0 m and the spacing between bushes in the row was0.5. Plots were separated by 1.5 m in the row. The plant density was thus 6667/ha.

Treatments

Treatments were foliar sprays of sulphur applied just before grape emergence or at the end of flowering or at both times as shown in Table 1. Treatments were applied at the appropriate time for the particular variety.

Table 1. Treatments

Treatment	No of sulphur sprays	Timing (growth stage) of application	Dates of application (2004)		
			Tirran	Baldwin	Others
1	1	Before first grape emergence (GS C3-D)	11 May	15 April	21 April
2	1	End of flowering (GS I2-I3)	4 June	18 May	18 May
3	2	1 + 2	1 + 2	1 + 2	1 + 2
4	0	-	-	-	-

An 800 g/l sprayable concentrate (SC) formulation of sulphur was used at the same dose rate per unit area for all sprays (Table 2). The dose of the sulphur active ingredient applied was 10.0 kg/ha.

Table 2. Dose and concentration of sulphur			
a.i.	Product	Dose product (l /ha)	Conc. (ml/l)
Sulphur	United Phosphorus 800 g/l sulphur SC	12.5 l/ha	25 ml/l

Spray application
Spray were applied with a Cooper Pegler 2000 knapsack sprayer with a hand lance at 500 litres water/ha. 75 ml of spray was applied / bush. The applications gave good, near complete, spray cover.

Experimental design and layout
The same experimental plantation was used in 2004 as was used in 2003. The design of the original experiment (by J Fenlon, HRI) consisted of 10 four plot by four plot Latin squares, two squares per variety, each square containing four replicates of each of the four treatments. Each plot consisted of six bushes in a row with 0.5 m between bushes, with 1.5 m between plots and 3 m between rows. The 2004 treatments (numbers 1-4) were re-allocated orthogonally to the old set of treatments. The 2004 set of four treatments (1, 2, 3, 4) was superimposed on the 2003 set of four treatments (A, B, C, D). Unfortunately, six of the original Latin squares (those not marked with an asterisk) were unbalanced. The new allocation of treatments for the unbalanced squares was chosen to account fully for residual effects from the previous set of treatments and fully for differences between the rows as shown on this plan. This design was based on the ANOVA of the yields in 2003 which showed that the major block effects were between rows rather than within rows.

Meteorological records
Wet and dry bulb temperature were measured with a whirling psychrometer, wind speed and direction were taken before and after spraying. Full records were available from HRI-EM met station.

Table 3. Weather conditions at the time of spray application

Date	Temp ºC	Humidity %
15 April	17.0-17.5	39-47
21 April	17.0-18.0	49-55
11 May	12.0-13.0	88-90
18 May	20.5-25.0	53-59
4 June	21.0-23.0	55-67

Lomond-

D 3	B 1	C 4	A 2
C 2	A 4	B 3	D 1
A 1	C 3	D 2	B 4
B 2	D 4	A 3	C 1

Tirran*

C 1	D 4	A 3	B 2
A 2	B 3	C 4	D 1
B 4	A 1	D 2	C 3
D 3	C 2	B 1	A 4

Gairn-

A 1	C 4	D 2	B 3
C 2	A 3	B 4	D 1
D 4	B 1	C 3	A 2
B 2	D 3	A 4	C 1

Hope*

D 2	C 3	A 1	B 4
B 3	A 2	C 4	D 1
A 4	B 1	D 3	C 2
C 1	D 4	B 2	A 3

Baldwin-

B 4	C 1	A 2	D 3
D 2	B 3	C 4	A 1
C 3	A 4	D 1	B 2
A 3	D 4	B 1	C 2

Hope*

B 1	D 4	A 3	C 2
A 2	C 3	B 4	D 1
D 3	B 2	C 1	A 4
C 4	A 1	D 2	B 3

Baldwin-

C 1	B 2	A 3	D 4
D 2	A 4	B 1	C 3
B 3	D 1	C 4	A 2
A 1	C 2	D 3	B 4

Tirran*

A 4	D 3	B 2	C 1
B 1	C 2	A 3	D 4
D 2	A 1	C 4	B 3
C 3	B 4	D 1	A 2

Lomond-

C 3	A 2	D 4	B 1
B 2	D 3	C 1	A 4
D 1	B 4	A 3	C 2
A 1	C 4	B 3	D 2

Gairn-

B 1	C 3	A 4	D 2
C 4	D 1	B 2	A 3
D 3	A 2	C 1	B 4
A 1	B 3	D 4	C 2

Figure 1. Experimental layouts in 2003 (treatments A, B,C, D) and 2004 (treatments 1, 2, 3, 4). ← North

Assessments

Visual phytotoxicity symptoms: The plots were inspected for visual signs of phytotoxicity on 14 June 2004. A digital photograph of the symptoms on one bush in each plot to be taken.

Yields: Yields were recorded at harvest by hand picking and weighing the central 2 bushes in each plot. The fallen fruit on the ground under each bush was gathered and weighed separately for each bush. The fruit was harvested at the appropriate time for each variety, Baldwin on 13 July, Ben Gairn on 16 July and the other varieties starting on 9 August 2004.

Taint: A composite sample of 5 kg of fruit was taken from each treatment (= 20 samples) at harvest and sent to a commercial laboratory chosen by GlaxoSmithKline, for taint testing and measurement of sugar content and acidity. (The costs of taint testing and other measurements are not included in this work)

Growth: Growth will be determined by estimating the average length of extension growth at the end of the season. The length of each of the current season's shoots will be measured to the nearest cm on one bush in each plot (bush number 4). The total length of shoots on the bush will be calculated. Bush number 4 is the same bush on which previous measurements were made.

Statistical analysis

Yields: Analysis of variance was done on the total yield (picked + dropped fruit) per plot and on the log10 transformed yield as there was some evidence of increasing variability with increasing mean. The previous years treatments were included as 0/1 covariates and were highly significant, with the largest (negative) effect being for the full spray treatment in 2003. Although the analysis of the log transformed data was more rigorous,, the conclusions drawn from both analyses were very similar. Thus the untransformed analysis is reported here for simplicity

Results

Visual symptoms of phytotoxicity

On 14 June 2004, phytotoxicity symptoms were clearly visible on all the varieties except Ben Tirran (Figures 3a, 3b, 3c). The pre-grape emergence + end of flower sulphur treatments caused the most severe phytotoxicity followed by the end of flower treatment with the least phytotoxicity being caused by the pre-grape emergence treatment (Table 3). However, the severity of the symptoms differed markedly between varieties. Symptoms were most severe on Ben Gairn where the lower leaves were severely blackened followed by Baldwin. Ben Hope and Ben Lomond showed only slight symptoms and the effects of the treatments were barely perceptible on the Ben Tirran. The phytotoxicity caused leaf fall and stunted the growth of the plants.

Table 3. Relative severity of phytotoxicity symptoms on the 14 June 2004

		Sulphur treatment	
Variety	1.Pre-grape emerged	2 End flower	3. Pre-grape + after flower
Baldwin	Very slight	Slight	Moderate
Ben Gairn	Moderate	Severe	Very severe
Ben Hope	None	Very slight	Slight
Ben Lomond	None	Very slight	Slight
Ben Tirran	None	None	None

Effects of treatments on yield

There were strong treatment effects due to both variety and sulphur treatment. The general interaction between these treatments was not quite significant (p=0.087) even with the more rigorous analysis on the logarithmic scale but there did appear to be minor differences in the effects of treatments on the different varieties.

The yields of Ben Lomond and Ben Tirran did not appear to be reduced significantly by any of the sulphur treatments (Table 4). The pre-grape + after flower sulphur treatment (treatment 3) was the most phytotoxic, reducing yield by 19% averaged across all varieties, but by 27% on the most susceptible variety, Baldwin.

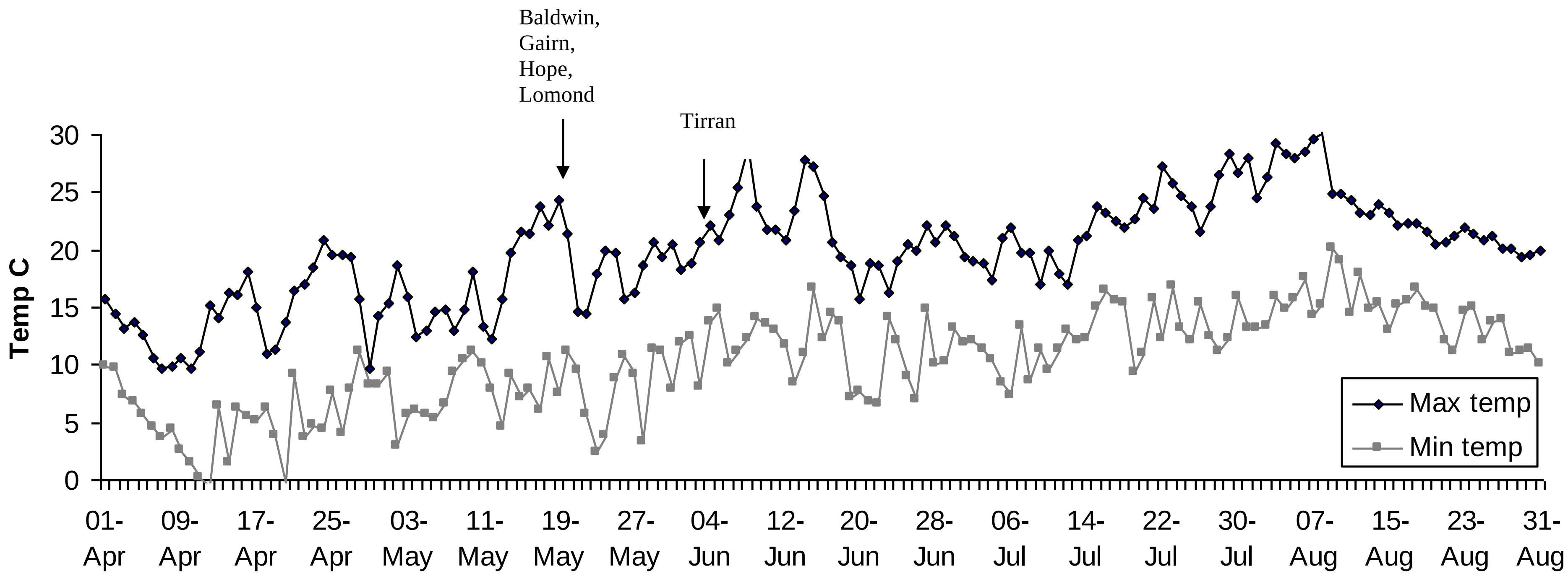

Figure 2. Daily maximum and minimum temperature (º C). The timings of the end of flower sprays are marked with arrows.

The end of flowering treatment (treatment 2) reduced yield by 13.5% on average with strongest treatment effects on Baldwin. The pre-grape emergence treatments to Baldwin significantly ($p < 0.05$) reduced yield by 17% compared to the untreated control for that variety but did not significantly reduce yields of the other varieties.

Discussion

Visual phytotoxicity symptoms were strongest on Ben Gairn but the greatest reductions in yield occurred on Baldwin. Baldwin appeared to be the most susceptible variety to sulphur phytotoxicity both in 2003 and 2004. However, results obtained in this 2004 experiment differ in several important respects from the results of the experiment in 2003. The phytotoxicity caused in 2004 was in general more severe, both in terms of the visual symptoms and the reductions in yield. In the 2003 experiment, the end of flowering caused only limited phytotoxicity, whereas in 2004, the end of flowering spray caused strong effects on the susceptible varieties. One explanation is that the severity of the phytotoxicity caused by the end of flower sprays in 2004 may have been exacerbated by the high temperatures (20.5-25.0 ºC) at or shortly after the time of treatment application. In the 2003 experiment, where phytotoxicity from post flowering sprays was less pronounced, temperatures at the time of application were lower, 14 ºC and 21 °C for the sprays at the end of flower and 2 weeks later respectively.

Table 4. Mean yields (t/ha)

	Sulphur spray treatment				
Variety	1.Pre-grape emerged	2 End flower	3. Pre-grape + after flower	4. None	**Mean**
Baldwin	1.62	1.31	1.42	1.95	**1.58**
Ben Gairn	1.22	1.11	0.88	1.34	**1.14**
Ben Hope	2.22	2.09	1.94	2.34	**2.15**
Ben Lomond	2.41	2.16	1.93	2.20	**2.17**
Ben Tirran	1.63	1.63	1.60	1.77	**1.66**
Mean	**1.82**	**1.66**	**1.55**	**1.92**	**1.74**

	SED	DF	LSD†
Variety grand means	0.126	5	0.323
Treatment grand means	0.063	102	0.125
Comparison within a variety	0.140	102	0.279
Other comparisons	0.175	18	0.367

† P = 0.05

	Baldwin	Ben Gairn
Pre-grape		
End flower		
Pre-grape + end flower		
Untreated		

Figure 3a. Photographs of phytotoxicity symptoms taken on 14 June 2004: Baldwin and Ben Gairn

	Ben Hope			Ben Lomond		
Pre-grape						
End flower						
Pre-grape + end flower						
Untreated						

Figure 3b. Photographs of phytotoxicity symptoms taken on 14 June 2004: Ben Hope and Ben Lomond

	Ben Tirran	
Pre-grape		
End flower		
Pre-grape + end flower		
Untreated		

Figure 3c. Photographs of phytotoxicity symptoms taken on 14 June 2004: Ben Tirran